Humanizing sociotechnical transitions through energy justice: An ethical framework for global transformative change

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ABSTRACT

Poverty, climate change and energy security demand awareness about the interlinkages between energy systems and social justice. Amidst these challenges, energy justice has emerged to conceptualize a world where all individuals, across all areas, have safe, affordable and sustainable energy that is, essentially, socially just. Simultaneously, new social and technological solutions to energy problems continually evolve, and interest in the concept of sociotechnical transitions has grown. However, an element often missing from such transitions frameworks is explicit engagement with energy justice frameworks. Despite the development of an embryonic set of literature around these themes, an obvious research gap has emerged: can energy justice and transitions frameworks be combined? This paper argues *that they can*. *It does so* through an exploration of the multi-level perspective on sociotechnical systems and an integration of energy justice at the model's niche, regime and landscape level. It presents the argument that it is within the overarching process of sociotechnical change that issues of energy justice emerge. Here, inattention to social justice issues can cause injustices, whereas attention to them can provide a means to examine and potential resolve them.

1. Introduction

Amidst serious sustainability challenges, transitions frameworks have evolved to either conceptualize or facilitate decarbonised energy systems that provide both security of supply and universal access to energy; a process that it is widely acknowledged will require new ways of producing, living and working with energy (Bridge et al., 2013; Heffron and McCauley, 2018; IEA, 2008; Mernier, 2007). In aiming to implement sociotechnical solutions, governments are increasingly utilising the language of transitions, and the concept has begun to feature in the energy policies of countries including Denmark, Switzerland and the United Kingdom (UK) (Foxon, 2013; Lovell, 2007; Bolton and Foxon, 2015). In tandem, although not explicitly termed as such, key aspects of energy justice debates have been discussed, and in some cases, remedied, since at least the late 1970s and early 1980s (Halff et al., 2014; Barbour, 1980; Smil and Knowland, 1980; Richards, 1981; Parfit, 1981; Barry, 1981; Perez-Guerrero, 1982; Weiberg, 1985). This paper identifies where transitions focuses are present, the resultant material and social transformations are imbued with contestations over what is just, equitable, and right. Thus, it calls for greater engagement with the three-tenet energy justice approach (distributional justice,

procedural justice and justice as recognition) when planning for more sustainable transitions. "By "energy transition" we mean "a change in an energy system, usually to a particular fuel source, technology, or prime mover (a device that converts energy into useful services, such as an automobile or television)" (Sovacool, 2016). By "transformation" or "transformational change" we refer to complex, unpredictable, frequently unprecedented and radical outcomes (Roggema et al., 2012: 2530)."

Scholars frequently envision the process by which sustainability transitions take place to be one of transformative change through transformative innovation (Hiteva and Sovacool, 2017; Schot and Steinmuller, 2016; Markard et al., 2012; Wilson and Tyfield, 2018; Wilson, 2018; Geels, 2018; Dütschke and Wesche, 2018). As a result, those advocating for transformational change sometimes argue that it has the potential to present more inclusive, robust solutions to sustainability challenges because it involves stakeholders from the outset, whether they are large organisations or small NGO groups that can effect grassroots change (Schot and Steinmuller, 2016). For instance, Linnenluecke et al. (2017) identify that planning for transformational change recognises that environmental challenges present opportunities to meet the (currently unmet) needs of those at the 'bottom of the

pyramid' – including the poorest of the poor (see also Bezboruah and Pillai, 2013; McAlpine et al., 2015; Tebo, 2005). Lawhon and Murphy (2011) outline that the concerns of small groups can be overruled by political or investor interests. There appears, then, emerging consideration for particular sectors of society who are seen to deserve more just outcomes.

Yet despite ongoing debates about ethics or justice across many fields of literature (including extended discussions between antagonist camps that have gone on across the history of political philosophy), one social element missing from transitions frameworks is explicit, practice-oriented engagement with the energy justice concept and related approaches to justice concerns. Eames and Hunt (2013) draw attention to the fact that considerations of equity and justice are underrepresented within the sociotechnical transitions literature and the wider energy transitions debate, despite the fact that the concept of sustainable development, the target of many transition plans, is inherently rooted in these core notions (Hopwood et al., 2005). Transitions literatures can also fail to give due consideration to issues of landscape, health and existing property values too (Jefferson, 2017).

Failure to adequately engage with questions of justice throughout the transition process is dangerous. It may lead to aggravated poverty, entrenched gender bias and non-participation as outcomes or by-products of 'blinkered' decision-making. Indeed, without a focus on justice, transitions may fail to acknowledge the burdens of having too much energy, such as waste, over-consumption and pollution, or from not having enough, where some individuals lack access, are challenged by under-consumption and poverty, and may face health burdens and shortened lives as a consequence of restricted energy choices (Sovacool et al., 2016a). This paper therefore utilizes the energy justice concept as a way of engaging with these ethical dilemmas *within* pre-existing transitions frameworks.

The paper proceeds as follows. The next section gives brief background on the format of the energy justice concept and one of the most dominant transitions models, the multi-level perspective (the MLP) on socio-technical systems—text we purposefully keep short both as it will largely be familiar to readers of this journal, and also to allow a focus on our main areas of development. Following this, the proceeding sections deliver the core conceptual advances, a proposed structure for linking the energy justice and technological innovation within the MLP. The final section concludes with a synthesis of the earlier arguments and a reflection on future research.

Throughout, we present three main claims, each coinciding with a level in the MLP model; the niche, regime, and landscape:

(1) That the energy justice concept can expose exclusionary and/or inclusionary technological and social niches before they develop, leading to potentially new *and* socially just innovation;
(2) That in addition to using the MLP to describe regimes, the energy justice framework provides a way for these actors to normatively judge them, potentially destabilising existing regimes using moral criteria;
(3) That framing energy justice as a matter of priority at the landscape level could exert pressure on the regime below, leading to the widespread reappraisal of our energy choices, and integration of moral criteria.

Across all of its parts, the paper emphasises the need for *socially just* sustainable energy policy as part of the re-imagined transition policy agenda. We frame this as a fundamentally political process as recognition that energy justice can only be inserted into the MLP process if there is political support for it and if we understand political tensions and trade-offs it presents. Whilst several studies have emerged that consider the role of energy justice in the sociotechnical transitions process (Mullen and Marsden, 2016; Eames and Hunt, 2013; Fuller and Bulkeley, 2013; McLaren et al., 2013), we believe this is the first to explore the role of energy justice in the MLP model.

2. New directions: Integrating energy justice and sociotechnical transitions theory

First, we briefly describe the energy justice challenge and framework and the MLP model before Section 3 goes on to explore the approach to and benefits of combining them.

2.1. The energy justice dimension

The origins of the energy justice literature is largely reported as coming from activist accounts of energy issues using the environmental justice frame - a precursor to the energy justice concept which shares overlapping philosophical groundings (Jenkins, 2018; McCauley, 2018e; McCauley et al., 2013). Specifically, as environmental justice is commonly defined as the distribution of environmental hazards and access to all natural resources; it includes equal protection from burdens, meaningful involvement in decisions, and fair treatment in access to benefits (see Hofrichter, 1993; Hockman and Morris, 1998; Low and Gleeson, 1998; Schlosberg, 1999). This approach forms the basis of the energy justice approach and framework. However, mentions of its core notions also appear elsewhere, including in the guise of the "three A's" of availability, accessibility and affordability. In this latter context, availability indicated the technical availability of a particular form of energy; accessibility the opportunity of those in a particular geographic location to access it and its associated services; and affordability the capacity of whole populations and sections therein to afford such energy services (see Goldemberg et al., 2000, which lists equity as one of the first goals of society, Johansson and Goldemberg, 2002; Reddy, 1985).

Across all literatures, key arguments around energy transitions have emerged, including considerations of the political economy of actors involved—the incumbents who stand to win or lose from transition processes, for example, and as a follow-on consideration, the support necessary for communities and businesses going through socio-technical change (see Harvey, 1996; Barnett, 2016; Young, 1990; Walker and Bulkeley, 2006; Walker, 2012, Schlosberg, 2013, 2004). Yet, on the whole, the 'socio-' or social element is frequently missing in the transitions literature and transition plans (see Sovacool et al., 2016a; Jamieson, 2014; Markowitz and Shari, 2012; Swilling and Annecke, 2012; Newell and Mulvaney, 2013; Goldthau and Sovacool, 2012; Hiteva and Sovacool, 2017). Eames and Hunt (2013: 58) note in this regard, that even 'a "low-carbon" transition has the potential to distribute its costs and benefits just as unequally [as historical fossil-based transitions] without governance mindful of distributional justice' or, as an extension, without attention to the issues of justice as recognition and due process – energy justice tenets we explore below. We argue that the energy justice concept provides one way of filling this gap.

Calls for transitions dynamics geared towards questions of ethics and justice must include concern for fairly distributing energy infrastructure and services, allowing equal access to decision-making, and fostering crosscutting participation of marginalised groups – a wider conception of the causes and forms of injustice present in current transitions thinking. This may also include consideration of the likely future wishes of those currently marginalised – their (and their descendants') wish to see landscapes and historical assets in the same way that proceeding generations have done, for example (Jefferson, 2017). Echoing these areas of focus, we limit the philosophical groundings of energy justice to distributional justice, procedural justice and recognition-based tenets. We utilise the framework of Fuller and Bulkeley (2013) who focus on the application of distributional justice and procedural justice tenet considerations in energy justice, based on the works of Rawls (1971), and, in line with McCauley et al. (2013), add to this a 'recognition-based' approach from the works of Fraser (1999, 2014).

Distributional justice[1] is concerned with the impacts of infrastructure, justice as recognition represents a concern for processes of

disrespect, stigmatisation and othering—questioning who is, or who is not, included in these decisions, and procedural justice investigates the mechanisms through which those decisions occur (Jenkins et al., 2016a, 2016b; McCauley et al., 2016, 2013).

We identify that applying these three concepts at each stage of the MLP framework provides opportunities to expose injustices, followed by the development of new means to solve them—power analysis, alternative political economic proposals, an understanding of hegemony, and capacity to do politics/build coalitions to begin to move towards solving problems, for example.

Practically speaking, energy justice is increasingly characterised as a conceptual, analytical *and* policy-oriented decision-making tool (see Sovacool and Dworkin 2014; Jenkins et al., 2017a; McCauley, 2018c and all papers from a recent Energy Justice special issue in *Energy Policy*). As one example, Heffron et al. (2015: 172) develop an energy justice metric, which is designed to connect with economists through quantitative analysis of energy justice, allowing it to be evaluated in monetary terms. Furthermore, Sovacool and Dworkin (2014) and Sidortsov and Sovacool (2015) offer an energy justice checklist, which provides a 'key questions' guide for energy decision-makers that challenges them to think about different moral criteria when developing energy projects. In this regard, the energy justice concept moves past academic discourse to non-academic application, including engagement with lawyers, economists and policy-makers (Jenkins et al., 2017a; Heffron et al., 2015; Sovacool and Dworkin 2014; Sovacool et al., 2014; Jenkins et al., 2016b). For this reason, it is thought of as an increasingly political phenomenon. To quote Healy and Barry (2017: 452) it "not simply a technological or indeed a sociotechnical matter. Indeed, since it is characterised by issues of power, distribution of and access to resources, political economy, and so on, it can be described as a deeply political struggle". As we go on to argue, each of these roles—conceptual, analytical, and politically-oriented decision-making—can be implemented through the distribution, procedure and recognition framework at each stage of the MLP approach to transitions.

2.2. The multi-level perspective dimension

One of the most prominent conceptual approaches to the sociotechnical transitions literature is the multi-level perspective, or the MLP[2] (see Cherp et al., 2018). The sociotechnical transitions literatures were predominantly developed by the 'Dutch school of transition studies' as a mode of governance for sustainable development (Jørgensen, 2012; Loorbach and Rotmans, 2010; Kern and Smith, 2008). This governance focus means that the socio-technical literature increasingly acknowledges the political dynamics related to the process through which innovations scale, diffuse or entrench. We focus here on the most prominent socio-technical transitions framework, the multi-level perspective (MLP). The MLP takes the form of a series of nested levels, the niche, regime, and landscape (Fig. 1), which aim to provide a contextual account of technological change and systems innovation over time (Bridge et al., 2013; Geels, 2002). According to Geels (2010), these levels refer to heterogeneous configurations of increasing stability. In mobilising geographical metaphors, they aim to provide a contextual account of technological change and systems innovation over time (Bridge et al., 2013; Geels, 2002). Geels (2002) stresses that these different levels do not represent ontological descriptions of reality, but instead offer analytical and heuristic concepts to aid the understanding of sociotechnical change. They represent, therefore, levels of structural

and temporal scale, rather than geographic, administrative or other types of levels (Grin et al., 2011).

The MLP's niche is characterised as the lowest but most dynamic level, and it is typically considered to be the site where radical, revolutionary innovation is developed and generated (Geels, 2002; Smith et al., 2010). In fulfilling this role, niches have been conceptualised as protected spaces, specific markets for example, within which radical innovations can develop without selection pressure from the prevailing regime (Kemp et al., 1998).

The sociotechnical regime, or the meso-level of the MLP, comprises dominant institutions and technologies, and reflects the prevailing set of routines or practices that create and sustain technological systems (Foxon, 2013). It is this level that creates the existing stability of technological development (Geels, 2002), and changes slowly and 'normally' under the influence of niche and regime dynamics (Smith et al., 2010). The core concept of the regime is that it imposes logic and direction for sociotechnical change along clear pathways of development (Markard et al., 2012).

The third stage of the MLP model, the macro-level landscape, is theorised as containing slow changing external factors (Geels, 2002) – broader trends and global events, and the environmental, socio-economic, and cultural context, within which actors and institutions are situated (Lachman, 2013; Smith et al., 2005). This level represents the broader political, social and cultural values and institutions of society (Foxon, 2013); so called quasi-autonomous macro-dynamics (Grin et al., 2011).

For a fuller review of all three levels, see Geels et al. (2017). It is the interplay and dynamic between these three levels that creates or constrains technological transitions. It is only when developments at all three levels coincide that transition occurs (Verbong and Geels, 2007), with, according to current interpretations, the main drive for change occurring between the regime and the niche (Geels and Schot, 2007). Thus, overall, the MLP examines and simplifies the interactions between niche-innovations and existing regimes, situated within a broader landscape environment.

3. Energy justice at the niche level

The energy justice concept can expose exclusionary and/or inclusionary niches before they develop. We say this, as acknowledgement that whilst new renewable innovations are designed to deliver sustainability, without attention to issues of energy justice, niches may become 'exclusionary niches'. New innovations funded by large companies can lead to the exclusion of poor, indigenous communities, for example, resulting in energy justice externalities, for example recently with shale gas technologies (Cotton et al., 2015; McCauley, 2018d). We provide the short examples of electric vehicles and wind energy to illustrate our case. Before doing so however, it is necessary to address *how* this is possible. Alongside the brief mention of energy justice metrics or frameworks above, several examples are emerging. Here we refer to one: reframing. The transitions literature notes that reframing at the niche level can lead to higher level changes in social norms and values (Sol et al., 2017). To this end, Healy and Barry (2017) reference the need to shift from framings focused on energy justice, sustainability and democracy to energy *injustice, unsustainability* and *a lack* of democracy. By altering this approach, they outline that energy transitions become "a more radical, systemic and politically oppositional project" (Healy and Barry, 2017). One clear example is the fossil fuel divestment movement, which is a response to unsustainability and injustice. Framing then, can be one tangible approach for achieving politically aware (or tactical) niche developments. In contrast, failure to change political and economic conditions can, in certain circumstances, lead to stranded assets and negative emissions (Sovacool and Scarpaci, 2016).

In order to be considered 'transitional', a technology is normally identified as stemming from radical innovation (Genus and Coles, 2008) (although some transition technologies are a repurposing of

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[1] We note here that we use the term 'distributional justice' in reference to the tenet framework presented by McCauley et al. (2013) and not in reference to a distributional form or theory of justice, which does not exist. Rather, it is distributive justice.

[2] The three other major frameworks are transition management (Kern and Smith, 2008; Loorbach, 2010; Rotmans et al., 2001; Kemp et al., 2007), strategic niche management (Kemp et al., 1998; Raven and Geels, 2010; Smith, 2007) and technological innovation systems (Bergek et al., 2008; Jacobsson and Johnson, 2000; Hekkert et al., 2007).
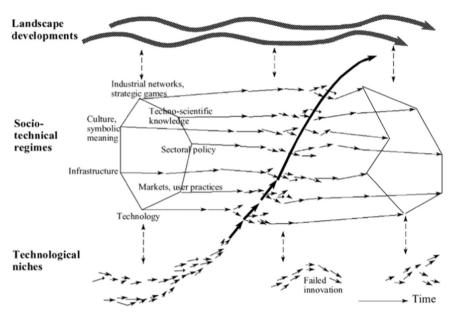
Fig. 1. A Dynamic multi-level perspective of STS.
(Source: Geels, 2002).

current or older technologies, including comparatively low tech solutions such as insulation retrofit and small-scale wind). We acknowledge that there can be some challenges differentiating niches from regimes. Despite being a comparatively new low-carbon technology in its commercial sense, wind or solar, for example, could arguably be classed as advanced enough to be 'regime'. Thus, we add the caveat that our aim is not to discuss what a new, 'niche' technology is, but only to demonstrate the role of energy justice considerations at the innovation, development and generation stage of technologies.

Analysis through the energy justice lens reveals that although electric vehicles (EVs) do have laudable environmental (and social) attributes, they can be exclusionary in the sense that they can perpetuate already widening gaps between the wealthy and poor, as well as potentially raising new forms and geographies of injustice – distributional and justice as recognition concerns.

The consumption of mobility and transportation modes already reflects, and may reinforce, patterns of recognition-based inequality. Banister and Anable (2009) noted that in the UK, for instance, those in the highest income quintile travel nearly three times further than those in the lowest quintile. As Wells (2012: 751) cautions, "mobility, or the lack thereof, has long been recognised as an important aspect of exclusion, inequality and poverty". A recent National Grid report presents a scenario in which electricity consumption continues to peak as EV's are taken up and relatively disengaged, affluent consumers are content to charge during peak times (National Grid, 2017). Moreover, transportation infrastructure and technology developments often benefit middle and upper class citizens because: they cater to their transportation needs (the development of suburban highways, for instance); pollution and congestion often build in poorer neighbourhoods; and poor residents are more likely to be displaced or have their neighbourhoods disrupted due to developments (Roth, 2004; Kaufmann and Jemelin, 2003).

It may come as no surprise that EVs, a niche within the existing transport regime, can perpetuate and solidify these disparities, as well as present potentially new ones. For instance, distributionally, EVs shift pollution from local tailpipes to power plants, making it a trans-boundary issue as pollution shifts to more regional distribution patterns (Buekers et al., 2014). Early adopters of EVs tend to be both wealthy and older than ordinary drivers (Wolf and Seebauer, 2014; Axsen and Kurani, 2013; Axsen et al., 2016), and to utilise them as second cars so that drivers had another, conventional vehicle at home to offset range

anxiety (Neubauer et al., 2012). A stated preference survey conducted in the UK revealed that higher income group is more likely to consider an EV as a second vehicle (Skippon and Garwood, 2011). In some cultures such as China, EVs are perceived as an elite and luxury consumer technology (Tyfield et al., 2014). Lastly, EVs as private cars still endorse a paradigm of private vehicle ownership. Those that rely on private transport have higher rates of diabetes, cardiovascular disease, and obesity than those who walk or take public transport (Woodcock et al., 2007). As one international team of health experts put it, 'increasing use of cars improves access for those individuals who are newly motorized but reduces access for others through danger and congestion' (Woodcock et al., 2007: 1082). In this context, private EVs can be as negative as private conventional vehicles.

Wind turbines, also, have sustainability benefits, but can be exclusionary in outsourcing, offshoring, or exporting pollution flows and embodied emissions of things like carbon dioxide. It is also misleading when done, not to take "embodied emissions" fully into account. Sovacool et al. (2016b) examined the externalities from manufacturing offshore and onshore wind turbines for use in Northern Europe, and found that wind energy has externalities across its construction and manufacturing. These included noxious emissions of hazardous air pollutants such as particulate matter, ozone, sulphur dioxide, and nitrogen oxide, as well as solid and electronic waste streams. These pollution flows both offset (in part) their environmental credentials and also result in significant emissions being outsourced to China and South Korea. Taking into account 'environmental profits and losses', the study estimated that China and South Korea accounted for about 80% of embodied emissions and resulting environmental damages across each type of turbine.

Applied at the development stage of this technology, an energy justice approach and analysis identifies such sources and forms injustices from the outset. This is not to disparage the drive to transition to low carbon and renewable technologies, which is a critical objective of energy justice (Heffron and McCauley 2017; McCauley, 2018a). This exposure of new injustices allows for the development of appropriate procedural justice mechanisms that cement the socially integrated, socially just development of the technology, with benefits for social acceptance and as an outcome, successful technology roll out. Appropriate framing can develop the political motivations to do so.

4. Energy justice at the regime level

In addition to applications in niches, the energy justice framework can support the current role of the MLP to describe regimes by providing a means for policy actors to normatively judge them—exposing unjust practices and resultantly, increasing regime 'humanisation'. We illustrate this first through the exploration of nuclear power and hydroelectric power production, regimes in which there is some consensus that technological development and lock-in raises issues of justice, or injustice. We identify that the metrics, frameworks, or checklists presented above – as well as the three-tenet framework of energy justice more generally – provide a means of normatively judging both planned and current energy and future sociotechnical regimes, leading to potential re-evaluation of our energy selection criteria. These approaches also recognise the need to politicise the actualisation of energy justice itself.

Nuclear output has increased from 0.9% to 4.8% between 1971 and 2016 in terms of its percentage share globally of total primary energy supply by fuel. China and Korea have notably experienced significant growth during this period, whilst the global leader of nuclear electricity production is the USA, closely followed by France (IEA, 2017). The power source is associated with a well-known set of risks and perceived injustices (extensive coverage of which is given by Endres, 2009; Cotton, 2009; Butler and Simmons et al., 2013; Hoffman, 2001; Shrader-Frechette, 2000, amongst numerous other authors). For Sovacool (2011) distributional justice and justice as recognition concerns include the fact that nuclear power is inherently associated with injustice through global events, increased incidents of cancers, dependence on finite uranium resources, toxic pollution of the environment and terrorist threats, amongst others. Of course, fossil fuels are explicitly associated with equally negative connections to human health implications over a much longer timeframe (Maiangwa and Agbiboa, 2013; Martinez et al., 2007; McCauley, 2018d). Despite these negative consequences, in some instances, nuclear energy has undergone explicit reframing by the pro-nuclear lobby in the face of the intersecting agendas of climate change, decarbonisation and sustainability, seeing it recast as a potential means of securing both security of supply and climate change stability, and a technology many are reluctantly willing to accept (Cotton, 2017; Pidgeon et al., 2008; Poortinga et al., 2006).

In 2008, for example, the United Kingdom (UK) government reversed its decision to decommission all nuclear power plants by 2025 in England and Wales, announcing instead that new nuclear would play a role in low carbon electricity generation (Doyle, 2011; Jenkins et al., 2016a). As a result the UK has developed a (now delayed) strategy to deliver around 16 GW of new nuclear by 2030 (BIS, 2013). Taebi and van de Poel (2015) outline that alongside the 30 countries that currently produce nuclear energy, another 45 have expressed interest in developing the technology. The ensuing questions of facility siting, hosting, the possible treatment of nuclear waste, the transfer of waste to the host sites, monitoring and final closure of stations all carry significant socio-technical and justice implications (Taebi et al., 2012; Landström and Bergmans, 2014).

As a second example, hydropower is a well established global energy regime as the leading renewable source for electricity generation globally (WEC, 2017). However, the establishment of a global regime in hydroelectricity has threatened ecosystems, water quantity and quality as well as human rights (McCauley, 2018b). The construction of hydroelectric power plants has resulted in social and ecological destruction and injustice (Kayir, 2017). The planning, construction and operation processes have dehumanised, dispossessed and impoverished communities. Examples are rife in current academic literature including (but not limited to) several African countries (Green et al., 2015), Canada (Loo, 2007), India (Khan, 2012), Japan (Maruyama, 2012), Laos (Mirumachi and Torriti, 2012), Mozambique (Sneddon and Fox, 2008), Portugal (Marques et al., 2015), Thailand (Sneddon and Fox, 2008) and Turkey (Hommes et al., 2016). From an energy justice perspective,

policy actors must explicitly consider the competing dichotomy of the 'morality of increasing energy provision' versus the 'morality of environmental and social protection'. Considering the inequalities of the latter, the sustainability of hydropower must surely be questioned.

Whilst the energy justice concept is limited in its capacity to entirely resolve the complex issues raised by nuclear power, in the context of its on-going expansion as part of a socio-technical transition, the procedural justice tenet plays an important role in making sure that these decisions are made with due process. Moreover, analysis of distributional and justice as recognition tenets may lead to the questioning of whether the 'morality of risk' or 'morality of climate change' is of most importance to wider society, and therefore whether nuclear is the right choice for future energy mixes. Depending on the outcome of these evaluations, this would have a knock-on effect on sustainable energy mixes.

5. Energy justice at the landscape level

Whilst much of the existing literature on sociotechnical systems has been dedicated to understanding niche innovations and regimes (Kemp et al., 1998; Lopolito et al., 2011; Smith and Raven, 2012), this has come at the expense of understanding landscape dynamics, the top level of the MLP. This section focuses on the idea that framing energy justice as a matter of priority at the landscape level could exert pressure on the regime below through larger cultural shifts, for example in attitudes toward multinational business or to state intervention in markets generally. This, in turn, could lead to the reappraisal of our energy choices and integration of moral decision-making criteria.

Despite their acknowledgement that the landscape contains static or slow changing factors, such as the physical climate and demographic shifts, Van Driel and Schot (2005) also attribute the landscape level with a degree of dynamism. This includes, predominantly, rapid external shocks such as war or oil price fluctuations as landscape dynamics. Whitmarsh (2012) also identifies a number of pressures on this landscape in the form of the environmental challenges of climate change, the economic challenges of oil prices, and the cultural challenge of value and behaviour change. This case can also be made using the example of nuclear energy. Hermwille (2016); Markard et al. (2016); Cotton (2014) demonstrate that the rapid external shocks of the Fukushima nuclear disaster had significant impact on the energy sectors in Japan, Switzerland and Germany, with strong effects for the on-going structural change of sociotechnical systems.

Geels (2010: 495) explains that niches, despite being relatively slow moving, can break through if the landscape level 'creates pressures on the regime that lead to cracks, tensions and windows of opportunity'. Thus, landscape factors can exert pressure on the regime challenging regime stability (Morone et al., 2015). To illustrate such mechanisms, Kuzemko et al. (2016) outline that new scientific knowledge on climate change has placed pressure on the lower two levels of the MLP, fostering widespread change to low-carbon technologies. Furthermore, Leiss (1978) offers the classic example that the rise of consumer culture based on individual definitions of needs, channelled through to expanding commodity consumption. Energy justice can arguably undertake a similar role, where the reframing of energy decision-making (including whether or not to accept fracking due to its justice implications, for example) as ethical issues can affect which technologies we select as part of our energy mix in the regime level. It follows that transition plans need to incorporate notions of energy justice.

Morone et al. (2015) offer a functionally-driven understanding of the landscape level, suggesting that it is an external context for actor interactions where a range of local, national and global stakeholders can create pressure upon the regime level through social, political and economic channels, in keeping with Kuzemko et al. (2016)'s climate change argument given above. Thus, it is the framing of energy justice as a matter of priority alongside the motivations of energy security and environmental protection that could lead to reappraisal of our energy

choices, and integration of moral criteria.

From a global production viewpoint, a key injustice in energy is the over-reliance of today's global societies on the historically embedded production systems of fossil fuels to satisfy growing energy demands (McCauley, 2018c). According to the International Energy Agency (IEA, 2016), the world is producing more than double the quantity in terms of total primary energy supply today than in 1973. In both these early years and the interim period, fossil fuels heavily dominate the world's energy production. An adoption of energy justice at the landscape level would involve multiple institutions actively pursuing alternative fuels. For global consumption, organisations would prioritise energy access in the same way as water or food. As for individual systems, rather than national considerations of security of supply the global justice footprint of each natural system would be taken into account when deciding on whether to follow a given technology such as nuclear.

Of course, it would be remiss not to acknowledge that such a framing at the landscape level is a political process. Meadowcroft (2011: 73) writes, for instance, "that the politics of sustainability transitions [and by extension energy transitions] requires a redefinition of societal interests and this implies political engagement to build re-form coalitions, create new centres of power, buy off powerful lobbies, isolated die-hards, compensate losers, and so on". As an illustration, the controversy around ExxonMobil's climate change communications is one example where the politicisation of fossil fuels provides scope for the energy justice approach. Supran and Oreskes' (2017) research outlined what may have been attempts from ExxonMobil to mislead the public concerning whether climate change is real and human caused. They claim this on three counts: (1) discrepancies in climate change communications between the types of documents ExxonMobil produced (whether internal or external, and depending on their degree of public accessibility), (2) the imbalance of different document types, and (3) factual misrepresentations in some advertorials. In light of such accusations #ExxonKnew became a public tool for expressing anger, later evolving into a petition to the United States Department of Justice and State Attorneys General. In this regard, litigation played a role in changing the norms around fossil fuels in response to public pressure. Energy justice can take on a similar role and build on and contribute to such instances.

6. Conclusions, policy recommendations and recommendations for future research

Energy decisions are all too frequently made in a moral vacuum, culminating in a strong normative case for combining the literature on sociotechnical transitions with concepts arising from energy justice. Moreover, we illustrate that energy justice can play a role at each level of one of the more expansive sociotechnical transitions frameworks, the MLP. Within this latter contribution, (1) the energy justice concept could expose exclusionary niches, (2) provide a means for actors to normatively judge regimes, and (3) through the framing of energy justice at the landscape level foster the reappraisal of our energy choices and integration of moral principles. Across all stages of this argument, we present a case for not only mitigating environmental impacts of energy production via sociotechnical change, but doing so in an ethically defensible, socially just way.

This challenge is not simple, of course. As a globally persistent problem, justice concerns share commonalities with various crises that, according to Grin et al. (2011), represent the dark side of dominant patterns of socio-economic-technological development, and are difficult to resolve. By the same token, processes that are firmly embedded in societal structures cause injustice, and as a consequence, dealing with injustice across our energy systems and sectors involves both innovative practices and structural adaptation. Nonetheless, the transitions approach could be mobilised to understand the complex dynamics of how processes of justice and injustice occur through the system, or can be managed. At the same time, an investigation of such processes would

provide a different lens through which transition scholars may understand, expand or renew core assumptions of sociotechnical transitions. In the countries were transitions lenses are taken in current policy approaches, we therefore recommend that justice be embedded as a core notion during both policy analysis and policy process. For countries exploring the evolution of poverty or justice concerns, transitions frames will provide profitable insights.

Of course, this argument comes with a number of caveats or 'practical pitfalls'. We identify two as indicative examples, acknowledging that many more may exist. As Lawhon and Murphy (2011) suggest that those wielding greater power in the sociotechnical system – political and industry elites – are likely to have their own interest favoured unless mechanisms are established to limit their influence. In this case, this may manifest as continued inattention to questions of ethics, morality and justice. Here we point to the idea that policy and industry groups have a higher *degree* of responsibility, not sole responsibility for just outcomes (Jenkins et al., 2017b). Therefore we cast wider society as the assessors of just energy practices. This reflects a policy recommendation by Jefferson (2008: 4123) that we must 'move away from the fashion of "big government", the empowerment of bureaucrats, and the "target culture" towards putting more power and financial resources into the hands of communities and the household'. Additionally, Eames and Hunt (2013: 50) note that transitions are not the outcome of a change in a single variable – the introduction of a new law, for example – but instead are the outcome of complex, mutually reinforcing, changes across several domains that involve societal actors (Fouquet, 2016; Grubler et al., 2016; Smil, 2016; Sovacool and Geels, 2016). In this regard it seems futile to believe that such approaches can foster truly 'just transitions' without the framing of energy justice as a core concern for wider society, and therefore a pressure on a range of regime actors.

Our caveats come as recognition of the intricacies of politics and political processes around energy transitions and energy justice. For as Meadowcroft (2009) highlights, long-term change is likely to be even messier and more contested than the transitions literature discusses. Indeed, there are likely to be political aspects that approaches such as the MLP are ill equipped to negotiate, and trade-offs that a tenet approach to energy justice cannot entirely resolve. Furthermore, Shove and Walker (2007) outline that despite extensive debate around the construction and democratic choice of visions of the future, the extent of the politics involved can be underplayed. Here, particular sociotechnical systems may appear unproblematic in their desirability but others are clearly not. In essence, there are conflicts around "the appropriate" and we must be cautious of sustainability as a legitimising discourse.

Nonetheless, despite the acknowledged difficulty of translating transitions from theory – which often occurs whether there is a concern for social justice or not – a social justice perspective *is* required to complement the conventional focus of energy studies on the costs of certain energy choices and technologies in order to fulfil the emergent moral vacuum in energy transitions research. This expands the normative drive for sustainable transitions to acknowledge the justice principles on which such concepts are founded.

Fairness must be at the heart of our policy response to growing energy demand. The global energy system presents humanity with three key challenges. We need, firstly, to secure enough resources to meet the rising energy demands from notably emerging economies such as India: the transition from fossil fuels to renewables should not threaten basic energy requirements. Such demands come from people, not just economies. Secondly, all parts of society must have access to energy. It is vital that energy is recognised as a necessary commodity for human life, just as much as food or water. The third challenge involves a global commitment to long term sustainable energy resource extraction, generation and waste related processes.

To conclude, in addition to the early exploration of this agenda introduced above, we identify two potential new areas of further

research that may advance these ideas and the field further. One, we advocate for more explicit consideration of agency, power and politics in transitions, and indeed energy justice, research (e.g. Geels, 2014). Two, we identify the need for greater consideration of non-traditional actors in transitions, including the roles of users (Schot et al., 2016), with due consideration given to marginalised groups as (non-)users. Beyond users, a consideration of non-dominant and non-state-based actors in shaping transition processes is also necessary (Seyfang and Smith, 2007). These elements and approaches have implications for understanding the dynamics of energy justice, but also of transitions in general, and they may fruitfully encourage that future scholars to refine their normative critical thinking faculties alongside their analytical and descriptive skills.

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References

Axsen, J., Kurani, K.S., 2013. Developing sustainability-oriented values: insights from households in a trial of plug-in hybrid electric vehicles. Glob. Environ. Change 23 (1), 70–80.

Axsen, J., Goldberg, S., Bailey, J., 2016. How might potential future plug-in electric vehicle buyers differ from current "Pioneer" Owner? Transp. Res. Part D: Transp. Environ. 47, 357–370.

Banister, D., Anable, J., 2009. Transport Policies and Climate Change. In: Davouidi, S., Crawford, J., Mehmood, A. (Eds.), Planning for Climate Change: strategies for mitigation and adaptation for spatial planners. Earthscan, London, United Kingdom, pp. 55–70.

Barnett, C., 2016. Towards a geography of Injustice. Alue ja Ymp. (Finn. Soc. Reg. Environ. Stud.) 2016 (1), 111–118.

Barbour, I.G., 1980. Technology, Environment, and Human Values. Praegar, Westport, CT.

Barry B., 1981. Intergenerational Justice in Energy Policy. Center for Philosophy and Public Policy Working Paper, University of Maryland.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., Rickne, A., 2008. Analysing the functional dynamics of technological innovation systems: a scheme of analysis. Res. Policy 37, 407–429.

Bezboruah, K.C., Pillai, V., 2013. 'Assessing the participation of women in microfinance institutions: evidence from a multinational study'. J. Soc. Serv. Res. 39, 616–628.

BIS, 2013. 'The UK's Nuclear Future. Industrial strategy: government and industry in partnership. BIS/12/627', Her Majesty's Government.

Bolton, R., Foxon, T.J., 2015. 'A sociotechnical perspective on low carbon investment challenges – insights for UK energy policy'. Environ. Innov. Soc. Transit. 14, 165–181.

Bridge, G., Bouzarovski, S., Bradshaw, M., Eyre, N., 2013. Geographies of energy transitions: space, place and the low-carbon economy. Energy Policy 53, 331–340.

Buekers, J., Van Holderbeke, M., Bierkens, J., Int Panis, L., 2014. Health and environmental benefits related to electric vehicle introduction in EU countries. Transp. Res. Part D. 33, 26–38.

Butler and Simmons, 2013. Framing Energy Justice in the UK: the Nuclear Case. In: K. Bickerstaff, et al. (Eds.). Energy Justice in a Changing Climate.

Cherp, A., Vinichenko, V., Jewell, J., Brutschin, E., Sovacool, B.K., 2018. Integrating techno-economic, socio-technical and political perspectives on national energy transitions: a meta-theoretical framework. Energy Res. Soc. Sci. 37, 175–190.

Cotton, M., 2017. Nuclear Waste Politics: an Incrementalist Perspective. Routledge, London.

Cotton, M., Muellerleile, C., Akers, J., 2015. Stakeholder perspectives on shale gas fracking: a Q-method study of environmental discourses. Environ. Plan. A 47, 1944–1962.

Cotton, M., 2009. Ethical assessment in radioactive waste management: a proposed reflective equilibrium-based deliberative approach. J. Risk Res. 12 (5), 603–618.

Cotton, M., 2014. 'Structure, agency and post-Fukushima nuclear policy: an alliance-context-actantiality model of political change'. J. Risk Res. 18 (3), 317–332.

Doyle, J., 2011. 'Acclimatizing nuclear? Climate change, nuclear power and the reframing of risk in the UK news media'. Int. Commun. Gaz. 73, 107–125.

Dütschke, E., Wesche, J.P., 2018. The energy transformation as a disruptive development at community level. Energy Res. Soc. Sci. 37, 251–254.

Eames, M., Hunt, M., 2013. Energy justice in sustainability transitions research. In:

Bickerstaff, K., Walker, G., Bulkeley, H. (Eds.), 'Energy Justice in a Changing Climate: Social Equity and Low-carbon Energy'. Zed books, London.

Endres, D., 2009. 'From Wasteland to waste site: the role of discourse in nuclear power's environmental Injustices'. Local Environ.: Int. J. Justice Sustain. 14 (10), 917–937.

Foxon, T.J., 2013. Transition pathways for a UK low carbon electricity future. Energy Policy 52, 10–24.

Fraser, N., 1999. Social justice in the age of identity politics. In: Henderson, G. (Ed.), Geographical Thought: A Praxis Perspective. Taylor and Francis, London, pp. 56–89.

Fraser, N., 2014. 'Justice Interruptus'. Routledge, London.

Fuller, S., Bulkeley, H., 2013. Energy justice and the low-carbon transition: assessing low-carbon community programs in the UK. In: Bickerstaff, K., Walker, G., Bulkeley, H. (Eds.), Energy Justice in a Changing Climate: Social Equity and Low-carbon Energy. Zed books, London.

Fouquet, R., 2016. Historical energy transitions: speed, prices and system transformation. Energy Res. Soc. Sci. 22, 7–12.

Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Res. Policy 31, 1257–1274.

Geels, F.W., Schot, J., 2007. Typology of sociotechnical transition pathways. Res. Policy 36 (3), 399–417.

Geels, F.W., 2018. Disruption and low-carbon system transformation: Progress and new challenges in socio-technical transitions research and the multi-level. Perspect., Energy Res. Social. Sci. 37, 224–231.

Geels, F.W., 2010. 'Ontologies, sociotechnical transitions (to sustainability), and the multi-level perspective'. Res. Policy 39 (4), 495–510.

Geels, F.W., 2014. 'Regime resistance against low-carbon transitions: introducing politics and power into the multi-level perspectives'. Theory, Cult. Soc. 31 (5), 21–40.

Geels, F.W., Sorrell, S., Schwanen, T., Jenkins, K., Sovacool, B.K., 2018. 'Reducing demand through low-energy innovation: a sociotechnical review and critical research agenda'. Energy Res. Soc. Sci. 40, 23–35.

Genus, A., Coles, A., 2008. Rethinking the multi-level perspective of technological transitions. Res. Policy 37 (9), 1436–1445.

Goldemberg J., et al. 2000. World Energy Assessment: Energy and the challenge of sustainability', United Nations Development Programme, New York.

Goldthau, A., Sovacool, K.B., 2012. The uniqueness of the energy security, justice, and governance problem. Energy Policy 41, 232–240.

Green, N., Sovacool, B., Hancock, K., 2015. Grand designs: assessing the African energy security implications of the grand Inga Dam. Afr. Stud. Rev. 58, 133–158.

Grin, J., Rotmans, J., Schot, J., 2011. On patterns and agency in transition dynamics: some key insights from the KSA programme. Environ. Innov. Soc. Transit. 1, 76–81.

Grubler, A., Wilson, C., Nemet, G., 2016. Apples, oranges, and consistent comparisons of the temporal dynamics of energy transitions. Energy Res. Soc. Sci. 22, 18–25.

Halff, A., Sovacool, B.K., Rozhon, J. (Eds.), 2014. 'Energy Poverty: Global Challenges and Local Solutions. Oxford University Press, Oxford.

Harvey, D., 1996. Justice, Nature and the Geography of Difference. Blackwell, Oxford.

Healy, N., Barry, J., 2017. Politicizing energy justice and energy system transitions: fossil fuel divestment and a "just transition". Energy Policy 108, 451–459.

Heffron, R.J., McCauley, D., 2017. The concept of energy justice across the disciplines. Energy Policy 105, 658–667.

Heffron, R.J., McCauley, D., 2018. What is the 'Just Transition'? Geoforum 88, 74–77.

Heffron, R.J., McCauley, D., Sovacool, B.K., 2015. Resolving society's energy trilemma through the energy justice metric. Energy Policy 87, 168–176.

Hekkert, M., Suurs, R.A.A., Negro, S., Kuhlmann, S., Smith, R., 2007. Functions of innovation systems: a new approach for analysing technological change. Technol. Forecast. Soc. Change 74 (4), 413–432.

Hermwille, L., 2016. The role of narratives in sociotechnical transitions – Fukushima and the energy regimes of Japan, Germany, and the United Kingdom. Energy Res. Soc. Sci. 11, 237–246.

Hiteva, R., Sovacool, B., 2017. Harnessing social innovation for energy justice: a business model perspective. Energy Policy 107, 631–639.

Hockman, E.M., Morris, C.M., 1998. Progress towards environmental justice: a five-year perspective of toxicity, race, and poverty in Michigan, 1990–1995. J. Environ. Plan. Manag. 41 (2), 157–176.

Hoffman, S.M., 2001. Negotiating eternity: energy policy, environmental justice, and the politics of nuclear waste. Bull. Sci. Technol. Soc. 21 (6), 456–472.

Hofrichter, R. (Ed.), 1993. Toxic Struggles: The Theory and Practice of Environmental Justice'. New Society, Philadelphia.

Hommes, L., Boelens, R., Maat, H., 2016. Contested hydrosocial territories and disputed water governance: struggles and competing claims over the Ilisu Dam development in southeastern Turkey. Geoforum 71, 9–20.

Hopwood, B., Mellor, M., O'Brien, G., 2005. Sustainable Development: mapping Different Approaches. Sustain. Dev. 13, 38–52.

IEA, 2008. World Energy Outlook. International Energy Agency.

IEA, 2016. Statistics on Global Electricity Information, Paris.

IEA, 2017. Technology Roadmaps - Nuclear Energy 2015. OECD, Paris.

Jacobsson, S., Johnson, A, 2000. The diffusion of renewable energy technology: ananalytical framework and key issues for research. Energy Policy 28 (9), 625–640.

Jamieson, D., 2014. 'Reason in a Dark Time: why the Struggle Against Climate Change Failed — and What it Means for Our Future'. Oxford University Press.

Jefferson, M., 2008. Accelerating the transition to sustainable energy systems. Energy Policy 36 (11), 4116–4125.

Jefferson, M., 2017. Safeguarding rural landscapes in the new era of transition to a low carbon future. Energy Res. Soc. Sci. 37, 191–197.

Jenkins, K., 2018. Setting energy justice apart from the crowd: lessons from environmental and climate justice. Energy Res. Soc. Sci. 39, 117–121.

Jenkins, K., Heffron, R., McCauley, D., 2016a. The Political Economy of Energy Justice: a Nuclear Energy Perspective. In: Van de Graaf, T., Sovacool, B.K., Ghosh, A., Kern, F.,

Klare, M.T. (Eds.), The Palgrave Handbook of the International Political Economy of Energy. Macmillan Publishers Ltd., London, United Kingdom.

Jenkins, K., McCauley, D., Heffron, R., Stephan, H., Rehner, R., 2016b. Energy Justice: a Conceptual Review. Energy Res. Soc. Sci. 11, 174–182.

Jenkins, K., McCauley, D., Forman, A., 2017a. Energy justice: a policy perspective. Energy Policy 105, 631–634.

Jenkins, K., McCauley, D., Warren, C., 2017b. Attributing responsibility for energy justice: a case study of the Hinkley Point Nuclear Complex. Energy Policy 108, 836–843.

Jenkins, K., 2018. Setting energy justice apart from the crowd: conceptual insights from the environmental and climate justice movements. Energy Res. Soc. Sci. 39, 117–121.

Johansson T., Goldemberg J., 2002. Energy for sustainable development: A policy agenda. United Nations Development Programme, New York.

Jørgensen, U., 2012. Mapping and navigating transitions – the multi-level perspective compared with arenas of development. Res. Policy 41, 996–1010.

Kaufmann, V., Jemelin, C., 2003. Coordination of land-use planning and transportation: How much room to manoeuvre? Int. Soc. Sci. J. 55 (2), 295–305 (176).

Kayir, Ö., 2017. Violations Of water rights, socio-ecological destruction and Injustice In Turkey By hydro-electric power plants. Trans. Ecol. Environ. 200, 147–158.

Kemp, R., Loorbach, D., Rotmans, J., 2007. Transition management as a model for managing processes of co-evolution towards sustainable development. Int. J. Sustain. Dev. World Ecol. 14 (1), 78–91.

Kemp, R., Schot, J., Hoogma, R., 1998. Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management. Technol. Anal. Strateg. Manag. 10 (2), 175–195.

Kern, F., Smith, A., 2008. Restructuring energy systems for sustainability? Energy transition policy in the Netherlands. Energy Policy 36 (11), 4093–4103.

Khan, T., 2012. "Dam" the Irony for The greater common good: a critical cultural analysis of the Narmada dam debate. Int. J. Commun. 6, 194–212.

Kuzemko, C., Lockwood, M., Mitchell, C., Hogget, R., 2016. Governing for sustainable energy systems change: politics, contexts and contingency. Energy Res. Soc. Sci. 12, 96–105.

Lachman, D.A., 2013. A survey and review of approaches to study transitions. Energy Policy 58, 269–276.

Landström, C., Bergmans, A., 2014. Long-term repository Governance: a socio-technical challenge. J. Risk Res. 18 (3), 378–391.

Lawhon, M., Murphy, J.T., 2011. Sociotechnical regimes and sustainability transitions: insights from political ecology. Prog. Hum. Geogr. 36 (3), 354–378.

Leiss W., 1978. The limits to satisfaction, Marion Boyars.

Linnenluecke, M.,K., Verreynne, M., de Villiers Scheepers, M.,J., Venter, C., 2017. A review of collaborative planning approaches for transformative change towards a sustainable future. J. Clean. Prod. 124 (4), 3212–3224.

Loo, T., 2007. Disturbing the peace: environmental change and the scales of justice on a northern river. Environ. Hist. 12, 895–919.

Loorbach, D., Rotmans, J., 2010. The practice of transition management: examples and lessons from four distinct cases. Futures 42 (3), 237–246.

Lopolito, A., Morone, P., Sisto, R., 2011. Innovation niches and sociotechnical transition: a case study of bio-refinery production. Futures 43 (1), 24–38.

Lovell, H., 2007. The governance of innovation in sociotechnical systems: the difficulties of strategic niche management in practice. Sci. Public Policy 34 (1), 35–44.

Low, N., Gleeson, B., 1998. Justice, Society, and Nature: an Exploration of Political Ecology. Routledge, London.

Maiangwa, B., Agbiboa, D.E., 2013. Oil multinational corporations, environmental irresponsibility and turbulent peace in the niger Delta. Afr. Spectr. 48, 71–83.

Markard, J., Raven, R., Truffer, B., 2012. Sustainability transitions: an emerging field of research and its prospects. Res. Policy 41 (6), 955–967.

Markard, J., Suter, M., Ingold, K., 2016. Sociotechnical transitions and policy change – advocacy coalitions in Swiss energy policy. Transitions 18, 215–237.

Markowitz, E.M., Shari, A.F., 2012. Climate change and moral judgment. Nat. Clim. Change 2, 243–247.

Marques, S., Lima, M., Moreira, S., Reis, J., 2015. Local identity as an amplifier: procedural justice, local identity and attitudes towards new dam projects. J. Environ. Psychol. 44, 63–73.

Martinez, M., Napolitano, D.A., MacLennan, G.J., et al., 2007. Impacts of petroleum activities for the Achuar people of the Peruvian Amazon: summary of existing evidence and research gaps. Environ. Res. Lett. 2, 65–71.

Maruyama, H., 2012. Ainu landowners' struggle for justice and the illegitimacy of the Nibutani Dam project in Hokkaido Japan. Int. Community Law Rev. 14, 63–80.

McAlpine, C.,A., Seabrook, L.M., Ryan, J.G., Feeney, B.J., Ripple, W.J., Ehrlich, A.H., Ehrlich, P.R., 2015. Transformational change: creating a safe operating space for humanity. Ecol. Soc. 20 (1), 56.

McCauley, D., 2018a. Alternative energy sources and energy justice: nuclear, hydro and wind. In: McCauley, D. (Ed.), Energy Justice. Springer, Basingstoke, pp. 51–74.

McCauley, D., 2018b. An energy justice road map - six key considerations. In: McCauley, D. (Ed.), Energy Justice. Springer, pp. 75–103.

McCauley, D., 2018c. Energy Justice: Re-balancing the Trilemma of Security, Poverty and Climate Change. Palgrave, Basingstoke.

McCauley, D., 2018c. Fossil Fuels and Energy Justice: coal, Oil and Gas. In: McCauley, D. (Ed.), Energy Justice. Springer, pp. 27–50.

McCauley, D., 2018d. Global energy justice: tackling systems of inequality in energy production and consumption. In: McCauley, D. (Ed.), Energy Justice. Springer, pp. 1–26.

McCauley, D., Heffron, R., Stephan, H., Jenkins, K., 2013. Advancing energy justice: the Triumvirate of Tenets. Int. Energy Law Rev. 32 (3), 107–110.

McCauley, D., Heffron, R.J., Pavlenko, M., Rehner, R., Holmes, R., 2016. Energy justice in the Arctic: implications for energy infrastructural development in the Arctic. Energy Res. Soc. Sci. 16 (1), 141–146.

McLaren, D., Krieger, K., Bickerstaff, K., 2013. Justice in energy system transitions: the case of carbon capture and storage. In: Bickerstaff, K., Walker, G., Bulkeley, H. (Eds.), Energy Justice in a Changing Climate: Social Equity and Low-carbon Energy. Zed Books, London.

Meadowcroft, J., 2009. What about the politics? Sustainable development, transition management, and long term energy transitions. Policy Sci. 42 (4), 323–340.

Meadowcroft, J., 2011. Engaging with the politics of sustainability transitions. Environ. Innov. Soc. Transit. 1 (1), 70–75.

Mernier A., 2007. Finding Common Ground in an Interdependent Energy World: The Role of the Energy Charter. International Energy Charter.

Mirumachi, N., Torriti, J., 2012. The use of public participation and economic appraisal for public involvement in large-scale hydropower projects: case study of the Nam Theun 2 Hydropower Project. Energy Policy 47, 125–132.

Morone, P., Lopolito, A., Anguilano, D., Sica, E., Tartiu, V.E., 2015. 'Unpacking landscape pressures on sociotechnical regimes: insights on the urban waste management system'. Environ. Innov. Soc. Transit. 20, 62–74.

Mullen, C., Marsden, G., 2016. Mobility justice in low carbon energy transitions. Energy Res. Soc. Sci. 18, 109–117.

National Grid, 2017. Future energy scenarios July 2017. National Grid.

Neubauer, J., et al., 2012. Sensitivity of battery electric vehicle economics to drive patterns, vehicle range, and charge strategies. J. Power Sources 209, 269–277.

Newell, P., Mulvaney, D., 2013. The political economy of the "just transition". Geogr. J. 179 (2), 132–140.

Parfit D., 1981. Energy Policy and the Further Future. Center for Philosophy and Public Policy Working Paper, University of Maryland.

Perez-Guerrero, M., 1982. Role of energy in the life of Mankind: lifestyles and distributive justice. Stud. Environ. Sci. 16, 551–564.

Pidgeon, F.N., Lorenzoni, I., Poortinga, W., 2008. Climate change or nuclear power – No thanks! A quantitative study of public perceptions and risk framing in Britain. Glob. Environ. Change 8, 69–85.

Poortinga, W., Pidgeon, N., Lorenzoni, I., 2006. Public perceptions of nuclear power, climate change and energy options in Britain: Summary findings of a survey conducted during October and November 2005. Tyndall Cent. Clim. Change Res. 1–22.

Raven, R., Geels, F.W., 2010. Socio-cognitive evolution in niche development: Comparative analysis of biogas development in Denmark and the Netherlands. Technovation 30 (2), 87–99.

Rawls, J., 1971. A Theory of Justice, (1991 revised edition). CUP, Cambridge.

Reddy, A.N., 1985. Energy issues and opportunities. In: Repetto, R. (Ed.), The global possible. Yale University Press, New Haven, pp. 371–373.

Richards D.A.J., 1981. Contractarian Theory, Intergenerational Justice, and Energy Policy. Center for Philosophy and Public Policy Working Paper, University of Maryland.

Roth, M.W., 2004. Whittier Boulevard, sixth Street bridge, and the origins of transportation exploitation in East Los Angeles. J. Urban Hist. 729–748.

Roggema, R., Vermeend, T., van den Dobbelsteen, A., 2012. Incremental change, transition or transformation? Optimising change pathways for climate apaptation in spatial planning. Sustainability 4, 2525–2549.

Rotmans, J., Kemp, R., Van Asselt, M., 2001. More evolution than revolution: Transitionmanagement in public policy. Foresight 3, 15–31.

Schlosberg, D., 1999. Environmental Justice and The New Pluralism: the Challenge of Difference for Environmentalism. Oxford University Press, Oxford, United Kingdom.

Schlosberg, D., 2013. Theorising environmental justice: the expanding sphere of a discourse. Environ. Polit. 22 (1), 37–55.

Scholsberg, D., 2004. Reconceiving environmental justice: global movements and political theories. Environ. Polit. 13 (3), 517–540.

Schot J., Steinmuller E.W., 2016. Framing Innovation Policy for Transformative Change: Innovation policy 3.0, Science and Policy Research Unit, University of Sussex.

Schot, J., Kanger, L., Verbong, G., 2016. The roles of users in shaping transitions to new energy systems. Nat. Energy 1, 16054.

Seyfang, G., Smith, A., 2007. Grassroots innovations for sustainable development: towards a new research and policy agenda. Environ. Polit. 16, 584–603.

Shove, E., Walker, G., 2007. 'CAUTION! Transitions ahead: politics, practice, andsustainable transition management. Environ. Plan. A 39 (4), 763–770.

Shrader-Frechette, K., 2000. Duties to future generations, proxy consent, intra- and intergenerational equity: the case of nuclear waste. Risk Anal.: Int. J. 20 (6), 771–778.

Sidortsov, R., Sovacool, B.K., 2015. Left out in the cold: energy justice and Arctic energy research. J. Environ. Stud. Sci. 5 (3), 302–307.

Skippon, S., Garwood, M., 2011. Responses to battery electric vehicles: uk consumer attitudes and attributions of symbolic meaning following direct experience to reduce psychological distance. Transp. Res. Part D. 16, 525–531.

Smil, V., 2016. Examining energy transitions: a dozen insights based on performance. Energy Res. Soc. Sci. 22, 194–197.

Smil, V., Knowland, W.E. (Eds.), 1980. Energy in the Developing World: The Real Energy Crisis. Oxford University Press, Oxford.

Smith, A., 2007. Translating sustainabilities between green niches and socio-technical regimes. Technol. Anal. and Strateg. Manag. 19, 427–450.

Smith, A., Raven, R., 2012. 'What is protective space? Reconsidering niches in transitions to sustainability'. Res. Policy 41 (6), 1025–1036.

Smith, A., Stirling, A., Berkhout, F., 2005. 'The governance of sustainable sociotechnical transitions'. Res. Policy 34 (1), 1491–1510.

Smith, A., Voß, J.-P., Grin, J., 2010. 'Innovation studies and sustainability transitions: the allure of the multi-level perspective and its challenges'. Res. Policy 39 (4), 435–448.

Sneddon, C., Fox, C., 2008. Struggles over dams as struggles for justice: the World Commission on Dams (WCD) and anti-dam campaigns in Thailand and Mozambique. Soc. Nat. Resour. 21, 625–640.

Sol, J., van der Wal, M.M., Beers, P.J., Wals, A.E.J., 2017. Reframing the future: the role

of reflexivity in governance networks in sustainability transitions. Environ. Educ. Res. 1–23.

Sovacool, B.K., 2016. How long will it take? Conceptualizing the temporal dynamics of energy transitions. Energy Res. Soc. Sci. 13, 202–215.

Sovacool, B.K., 2011. Contesting the Future of Nuclear Power: a Critical Global Assessment of Atomic Energy. World Scientific, Hackensack.

Sovacool, B.K., Dworkin, M.H., 2014. Global Energy Justice: Principles, Problems, and Practices. CUP, Cambridge.

Sovacool, B.K., Heffron, R.J., McCauley, D., Goldthau, A., 2016a. Energy decisions re-framed as justice and ethical concerns. Nat. Energy 1, 16–24.

Sovacool, B.K., Perea, M.A.M., Matamoros, A.V., Enevoldsen, P., 2016b. Valuing the externalities of wind energy: assessing the environmental profit and loss of wind turbines in Northern Europe. Wind Energy 19 (9), 1623–1647.

Sovacool, B.K., Sidortsov, E.V., Jones, B.R., 2014. Energy Security, Equality, and Justice. Earthscan, Abingdon, Oxon, United Kingdom.

Sovacool, B.K., Geels, F.W., 2016. Further reflections on the temporality of energy transitions: a response to critics. Energy Res. Soc Sci. 22, 232–237.

Supran, G., Oreskes, N., 2017. Assessing ExxonMobil's climate change communications (1977–2014). Environ. Res. Lett. 12 (8), 084019.

Sovacool, B.K., Scarpaci, J., 2016. Energy justice and the contested petroleum politics of stranded assets: policy insights from the Yasuní-ITT Initiative in Ecuador. Energy Policy 95, 158–171.

Swilling, M., Annecke, E., 2012. Just transitions: explorations of sustainability in an unfair world. UCT Press, South Africa.

Taebi, Van de Poel, I., 2015. The socio-technical challenges of nuclear power production and waste management in the post-Fukushima era: editors' overview. J. Risk Res. 18. pp. 267–272.

Taebi, B., Roeser, S., Van de Poel, I., 2012. The ethics of nuclear power: Social experiments, intergenerational justice, and emotions. Energy Policy 51, 202–206.

Tebo, P.,V., 2005. 'Building business value through sustainable growth'. Res.-Technol. Manag. 48, 28–32.

Tyfield, D., Zuev, D., Ping, L., Urry, J., 2014. Low Carbon Innovation in Chinese Urban Mobility: Prospects, Politics and Practices. STEPS Centre, Brighton (STEPS Working 71).

Van Driel, H., Schot, J., 2005. Radical innovation as a multi-level process: introducing floating grain elevators in the port of Rotterdam. Technol. Cult. 46 (1), 51–76.

Verbong, G., Geels, F., 2007. The on-going energy transition: lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004). Energy Policy 35, 1025–1037.

Walker, G., Bulkeley, H., 2006. Geographies of environmental justice. Geoforum 37, 655–659.

Walker, G., 2012. Environmental Justice: Concepts, Evidence and Politics. Routledge, London.

WEC, 2017. Hydropower in Global Perspective, London.

Weiberg, A.M., 1985. Immortal energy systems and intergenerational justice. Energy Policy 51–59.

Wells, P., 2012. Converging transport policy, industrial policy and environmental policy: the implications for localities and social equity. Local Econ. 27 (7), 749–763.

Whitmarsh, L., 2012. How useful is the Multi-Level Perspective for transport and sustainability research? J. Transp. Geogr. 24 (0), 483–487.

Wilson, C., 2018. Disruptive low-carbon innovations. Energy Res. Soc. Sci. 37, 216–223.

Wilson, C., Tyfield, D., 2018. Critical perspectives on disruptive innovation and energy transformation. Energy Res. Soc. Sci. 37, 211–215.

Wolf, A., Seebauer, S., 2014. Technology adoption of electric bicycles: a survey among early adopters. Transp. Res. Part A 69 (2014), 196–211.

Woodcock, J., Banister, D., Edwards, P., Prentice, A.M., Roberts, I., 2007. Energy and transport. Lancet 2007 (370), 1078–1088.

Young, I., 1990. Justice and the Politics of Difference. Princeton University Press, Oxford.